E. W. Berry and J. A. Gardner, Geological Laboratory, Johns Hopkins University.

The several Upper Cretaceous formations of the Middle Atlantic Coast represent all of the major divisions of the European series.

17. *Upper Cretaceous Floras of the World:* Edward W. Berry, Geological Laboratory, Johns Hopkins University.

The stratigraphic position of the more important of the Upper Cretaceous floras is indicated by a diagram.

18. *Observations on Amœba Feeding on Infusoria, and their Bearing on the Surface-Tension Theory:* S. O. Mast and F. M. Root, Zoological Laboratory, Johns Hopkins University.

Surface-tension is probably only a small factor in the process of feeding in Amœba.

19. *The Electromotive Force produced by the Acceleration of Metals:* Richard C. Tolman and T. Dale Stewart, Department of Chemistry, University of California.

Successful attempts have been made to change the relative position of positive and negative electricity in a piece of metal by subjecting it to a large retardation.

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## SPECIAL ARTICLES

### THE KATA THERMOMETER AS A MEASURE OF THE EFFECT OF ATMOSPHERIC CONDITIONS UPON BODILY COMFORT

It has been clearly demonstrated by numerous investigations that the objectionable effects of the air of a badly ventilated room are chiefly thermal rather than chemical in nature. At the same time it has been recognized that the ordinary thermometer is a very inadequate measure of the discomfort experienced in such a room because the heat loss from the body surface is influenced not only by the temperature of the surrounding air but also by the humidity present and the radiant heat which reaches the body, and above all by the movement of the air. The condition in a close room has been commonly compared with that which obtains outdoors on a muggy day in summer; yet it is clear that the outdoor temperature must be very much higher than the indoor temperature in order to produce a comparable degree of discomfort.

Dr. W. Heberden[1] pointed out these facts nearly a hundred years ago and suggested a way out of the difficulty by the observation of the rate of fall of a thermometer previously heated to a high temperature. He heated a thermometer to 100° F. and noted the number of degrees which it fell in ten minutes as a measure of "sensible cold." He records drops of from 8° to 22° in the first ten minutes.

The same device has recently been independently worked out by Dr. Leonard Hill in England[2] and the apparatus is now sold by Siebe Gorman and Company of Chicago under the name of the Kata thermometer.

The Kata thermometer outfit consists of two specially constructed thermometers with large bulbs and stems graduated from 86° to 110° F., one to be used as a dry and the other as a wet bulb thermometer. The bulbs are heated to about 110° and then placed in clips which hold them in a horizontal position, after drying the bare bulb on a clean cloth and jerking excess moisture off the silk covered one. The time taken to fall from 100° to 90° is then noted, best by the use of a stop-watch.

The rate of fall of both thermometers will obviously be affected by air movement and radiant heat as well as by air temperature, and that of the wet bulb by the humidity of the air as well. Dr. Hill believes that the combined influence of these factors will affect the Kata thermometers very much as it does the human body, and suggests a one-minute period for the wet bulb and a three-minute period for the dry bulb as upper limits for comfortable atmospheric conditions.

This instrument promises to be of so much assistance in the practical study of ventilation

[1] "An Account of the Heat of July, 1825; together with Some Remarks upon Sensible Cold," *Trans. Roy. Soc.*, London, 1826, Part II., p. 69.

[2] "The Physiology of the Open-Air Treatment," *The Lancet*, CLXXXIV., May 10, 1913, p. 1,283; see also O. W. Griffith, "Ventilation and Housing," *The Medical Officer*, XIII., June 19, 1915, p. 273.

problems that I have made a number of observations to determine how closely its records correspond with sensations of bodily comfort. These observations are presented in Tables I., II. and III. The first series was made indoors and outdoors in the country at Ipswich, Mass., during the month of August; the second in my laboratory at the American Museum of Natural History in New York (with and without the air current from a desk fan); and the

TABLE I[3]

| Observation | Date | Shade Temperature | Kata Times, Seconds. Dry Bulb | Kata Times, Seconds. Wet Bulb | Comfort Vote[4] | Remarks |
|---|---|---|---|---|---|---|
| 1 | 7/8 | 73° | 118 | 44 | 2.5 | Porch, under awning. Light wind. |
| 2 | 7/8 | 73° | 237 | 55 | 3.5 | Same as 1 but in direct sun. |
| 3 | 7/8 | 77° | 216 | 90 | 3.8 | Indoors, table, under lamp. |
| 4 | 8/8 | 68° | 82 | 36 | 2.0 | Porch. Cloudy day. Moderate wind. |
| 5 | 10/8 | 75° | 128 | 50 | 3.0 | Porch, in shade of house. Clear, after rain. Light breeze. |
| 6 | 10/8 | 75° | 268 | 42 | 3.8 | Same as 5 but in sun. More breeze. |
| 7 | 11/8 | 74° | 227 | 72 | 3.0 | Indoors. Draft from open door. |
| 8 | 13/8 | 75° | 196 | 67 | 3.7 | Porch. Cloudy. Air very damp. Light wind. |
| 9 | 13/8 | 75° | 105 | 43 | 2.7 | Same as 8 but at end of porch in stronger breeze. |
| 10 | 14/8 | 79° | 188 | 48 | 3.4 | Porch in shade. Moderate breeze. |
| 11 | 14/8 | 80° | 255 | 80 | 4.0 | Same as 10 but out of wind. |
| 12 | 16/8 | 82° | 180 | 42 | 3.7 | Porch in shade. Light wind. |
| 13 | 17/8 | 72° | 115 | 23 | 2.2 | Porch in shade. Strong breeze. |
| 14 | 21/8 | 77° | 143 | 48 | 3.6 | Porch in shade. Light breeze. |
| 15 | 21/8 | 77° | 159 | 37 | 3.4 | Same as 14. Porch in sun. Sky clouded. More breeze. |
| 16 | 22/8 | 89° | 49 | 25 | 2.0 | Porch. Cloudy day. High wind. |
| 17 | 23/8 | 79° | 320 | 94 | 4.7 | Indoors. Five people and lamp in room. |
| 18 | 29/8 | 66° | 176 | 67 | 2.2 | Indoors. Closed room. Rain outside. |
| 19 | 29/8 | 72° | 277 | 78 | 3.6 | Indoors. Before fire. |

[3] Observations made during month of August, 1915, at Ipswich, Mass.

[4] Average of vote of three to six observers, including four women, ages 90, 65, 38 and 36 and two men, ages 38 and 75.

TABLE II[5]

| Observation | Date | Shade Temperature | Kata Times, Seconds Dry Bulb | Kata Times, Seconds Wet Bulb | Comfort Vote[6] | Fan[7] |
|---|---|---|---|---|---|---|
| 20 | 1/9 | 71° | 177 | 68 | 3.2 | —— |
| 21 | Do. | 70° | 78 | 25 | 2.6 | First speed. |
| 22 | 3/9 | 79° | 355 | 95 | 3.7 | —— |
| 23 | Do. | 79° | 118 | 29 | 2.7 | Half speed. |
| 24 | 15/9 | 88° | 720 | 148 | 4.8 | —— |
| 25 | Do. | 87° | 215 | 50 | 4.0 | Half speed. |
| 26 | Do. | 87° | 223 | 45 | 3.8 | Over third speed. |
| 27 | 17/9 | 88° | 844 | 131 | 4.5 | —— |
| 28 | Do. | 88° | 260 | 41 | 4.0 | Half speed. |
| 29 | 23/9 | 72° | 233 | 69 | 3.8 | —— |
| 30 | Do. | 72° | 72 | 25 | 2.8 | Half speed. |
| 31 | 28/9 | 69° | 200 | 71 | 3.4 | —— |
| 32 | Do. | 69° | 71 | 22 | 2.6 | Half speed. |
| 33 | 29/9 | 72° | 220 | 62 | 3.2 | —— |
| 34 | Do. | 72° | 84 | 28 | 2.7 | Half speed. |
| 35 | 6/10 | 72° | 240 | 75 | 3.6 | —— |
| 36 | Do. | 72° | 72 | 28 | 2.6 | Half speed. |

TABLE III[8]

| Observation | Date | Shade Temperature | Kata Times, Seconds Dry Bulb | Kata Times, Seconds Wet Bulb | Comfort Vote[9] | Remarks |
|---|---|---|---|---|---|---|
| 37 | 22/10 | 66° | 200 | 62 | 3.1 | One window open. Sun shining. |
| 38 | Do. | 67° | 181 | 52 | 3.0 | Later. Windows closed. Sun clouded. Fan on.[10] |
| 39 | 2/11 | 61° | 122 | 48 | 2.2 | Windows closed. Fan on. |
| 40 | 5/11 | 61° | 151 | 52 | 3.0 | Windows closed. Fan on. |
| 41 | 5/11 | 64° | 148 | 49 | 2.9 | Later. Fan off. |
| 42 | 12/11 | 65° | 159 | 55 | 3.2 | Windows closed. Fan on. |
| 43 | 12/11 | 67° | 185 | 64 | 3.1 | Later. Fan off. |
| 44 | 26/11 | 69° | 170 | 58 | 3.4 | Windows closed. Fan on. |
| 45 | 26/11 | 71° | 196 | 51 | 3.4 | Later. Fan off. |

[5] Observations made in laboratory of Department of Public Health, American Museum of Natural History, New York, September and October, 1915.

[6] Average of vote of 3 to 6 observers, all males from 16 to 38 years of age.

[7] First observation on each date made in laboratory with windows closed. Second (and third of September 15) under same conditions but with a 15-inch colonial desk fan operating about 4 feet from thermometers and directed toward them.

[8] Observations made in physiological laboratory, Yale Medical School, through courtesy of Professor Yandell Henderson.

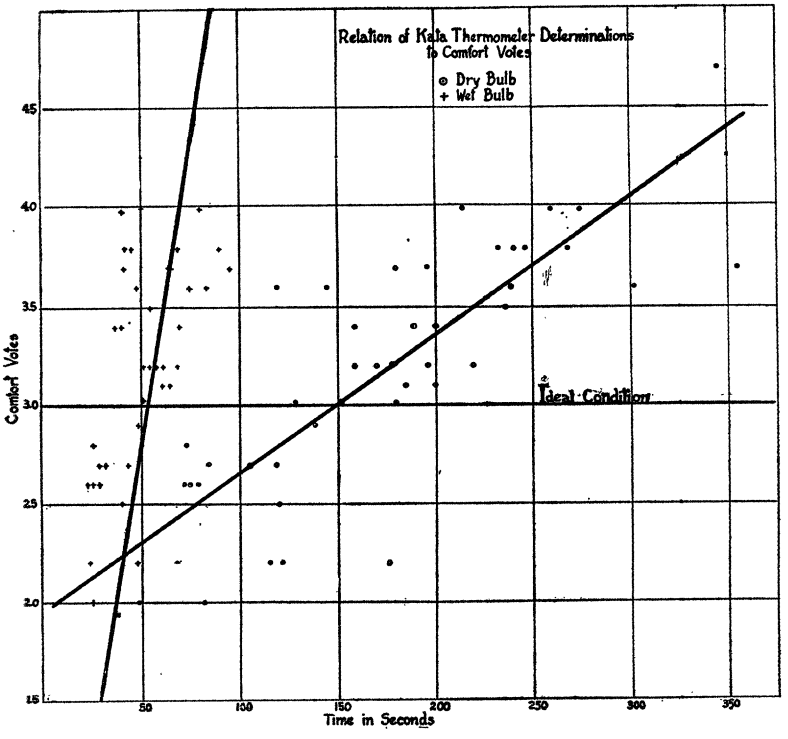
[9] Average of vote of 10 to 20 medical students.

[10] 22-inch exhaust fan in corner of ceiling.

third series in the physiological laboratory of the Yale Medical School, through the courtesy of Professor Yandell Henderson.

At the time each observation was made, from three to twenty observers were asked to express their opinion as to the comfortableness of the atmospheric conditions on a scale of five as follows: 1, cold; 2, cool; 3, ideal; 4, warm; 5, hot. The comfort vote in the table represents the average of the observers voting on each occasion.

With these exceptions the plotted points are not at all badly grouped about the calculated line, considering that we are dealing with so variable a factor as the sensation of comfort. A study of individual points which deviate widely from the straight line shows that of twelve cases in which the atmospheric conditions were voted as hotter than would be expected from the thermometer readings, every one was either outdoors in a wind or indoors in front of the electric fan (observations 6, 8, 10, 12, 14, 15, 21, 25, 26, 28, 30, 32). Of thirteen cases in which the atmospheric conditions were voted cooler than would be expected from the reading, on the other hand, only four were cases in which there was a strong current of moving air (observations 1, 3, 4, 7, 13, 16, 18, 19, 22, 33, 37, 38, 39). This probably means that whereas the ordinary thermometer leaves out entirely the effect of air movement, the Kata thermometer emphasizes it somewhat unduly.




The results of the comfort vote have been plotted against wet and dry bulb readings in the diagram, the straight lines representing the most probable curve as calculated from individual observations. Two records out of the forty-five (Nos. 24 and 27) have been omitted since these very high values (12 minutes and 14 minutes, respectively, for the dry bulb) fell far below the curve. The comfort vote fails to express such extreme conditions adequately.

On the whole, however, it seems clear that this instrument is of great value in measuring the actual influence of air conditions upon the body and is greatly superior to the ordinary thermometer for this purpose. Compare for instance observations 8 and 9, both made outdoors on a cloudy day, with an air temperature of 75°. In 8 the Kata thermometers and the observers were protected from the wind, while in 9 they were at the end of the porch in a breeze. The dry bulb times at these two points were 196 seconds and 105 seconds, respectively, and the comfort votes 3.7 and 2.7. In the first case it was uncomfortably warm, in the second too cool, with nothing in the reading of the ordinary thermometer to indicate any change. Again contrast observations 13 and 19, the first taken out of doors in a strong breeze, the second indoors before a fire. The ordinary thermometer registered 72° in each case, but in one instance the time for the fall of the Kata dry bulb was 115 seconds and the comfort vote 2.2; in the other case the dry bulb time was 277 seconds and the comfort vote 3.6. Out door conditions with ordinary thermometer readings of 75° (Nos. 5 and 9), 77° (No. 15), and 79° (No. 10) were more comfortable and showed lower Kata thermometer times than this room with a fire at 72°.

Most significant are the readings and the comfort votes in Table II., in which on each day conditions were noted, first without, and then with, the direct draft from an electric fan. In each case the ordinary thermometer either remained unchanged (or dropped one degree in two instances) while the Kata times and the comfort votes fell off enormously. On six different days, with ordinary thermometer readings varying from 69° to 79°, the comfort vote showed uncomfortably hot conditions and Kata dry bulb times over 170 without the fan and too cool conditions, and Kata dry bulb times under 120 with the fan turned on (observations 20–23 and 29–36). Even the condition of 87° on the ordinary thermometer (observation 26) was as comfortable and showed about the same Kata thermometer readings as were obtained without the fan at an air temperature of 72° (observation 29).

The curves as plotted suggest that the optimum for comfort (represented by an average vote of 3.0) falls close to the lower of the points suggested by Dr. Hill (45–60 seconds for the wet bulb and 150–180 seconds for the dry bulb). Too much stress can not of course be laid on a small number of observations such as are here reported, but the general value of the Kata thermometer seems sufficiently obvious to warrant its general use in the study of atmospheric conditions as they affect bodily comfort.[11]

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## THE AMERICAN PHILOSOPHICAL SOCIETY

THE general annual meeting of the American Philosophical Society was held on April 13, 14 and 15 during which nearly fifty papers were presented on a great variety of topics. The address of welcome was made by Dr. W. W. Keen, the president, who, with vice-presidents W. B. Scott and E. C. Pickering, presided at the various sessions.

On Friday evening a reception was held at the hall of the Historical Society of Pennsylvania, after which Dr. L. O. Howard, of Washington, gave a lecture "On Some Disease-bearing Insects."

Saturday afternoon was entirely devoted to a symposium on international law in its various aspects, five papers being presented.

The program and some abstracts of the papers follow:

THURSDAY, APRIL 13

*Opening Session—2 o'clock*

William W. Keen, M.D., LL.D., President, in the Chair

*The Popes and the Crusades:* DANA C. MUNRO.

*The Common Folk of Shakespeare:* FELIX E. SCHELLING.

*A Rare Old-Slavonic Missal:* J. DYNELEY PRINCE.

*On the Art of Entering Another's Body: A Theme of Hindu Fiction:* MAURICE BLOOMFIELD.

[11] Hill, Griffith, and Flack (*Phil. Trans. Roy. Soc. Lond.*, series *B*, Vol. 207, pp. 183–220) have recently published an important study in which the Kata readings are translated into fundamental physical units of millicalories of heat loss per square centimeter per second.